hy-gain® VII

by hy-gain

MODEL 3077
CITIZENS TWO—WAY RADIO
base station

Manufactured and Distributed by
Hy-Gain de Puerto Rico, Inc.
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Naguabo, Puerto Rico 00718

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PN 820145

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CHAPTER 1 - GENERAL INFORMATION

Introduction

This service manual contains all the information needed to service and repair the Hy-Gain VII transceiver (Model 3077). It includes an explanation of the theory of operation and alignment procedures. Revision, addendum, and errata sheets will be published as needed. Insert them as required in the manual.

The Hy-Gain VII is a full 23-channel transceiver designed and type accepted for Class D Citizens Radio Service, as designated by the Federal Communications Commission (FCC).

It is a completely solid-state base station, highly reliable, with low power consumption. Its crystal matrix frequency synthesizer provides immediate operation on all 23 channels. A built-in automatic noise limiter (ANL) is included to help reduce atmospheric noise. Output jacks for an optional telephone-style handset and an external speaker are also included. The unit operates from either 115 VAC (nominal) or 12 VDC (nominal) positive or negative ground.

Warranty Service Department

For help with technical problems, for parts information, and information on local and factory repair facilities, contact the National Service Manager. When you write, please include all pertinent information that may be helpful in solving your problem. Address your letter to:

Hy-Gain Warranty Service Department
4900 Superior Street
Lincoln, Nebraska 68504
ATTN: National Service Manager

The Warranty Service Department can repair any unit. Before shipping a unit contact the National Service Manager. Often a problem is field solvable with a little extra help. This can save you lost time and shipping costs. Limit factory returns to difficult problems.

How to Ship Returns

To return a unit, get a return authorization first. This is important. You will only delay the handling of your unit if you ship without it. If you must ship immediately, telephone or telex the National Service Manager, for expeditious service.

When you request return authorization, you may also request notification of completion of repairs. The notification will include a copy of the bill. Paying the bill before we return the unit, can save the cost of a COD fee.

For warranty repair, prepare a letter in duplicate containing the following information (for out-of-warranty repair, delete items 2 and 3):

1. your name and address
2. purchaser's name and address
3. proof of purchase
4. serial number
5. a complete description of the problem
6. the return authorization

Check the unit to see that all parts and screws are in place, and attach an envelope containing a copy of the letter directly to it so the information is not overlooked. Wrap the unit and envelope in heavy paper or put them in a plastic bag. If the original carton is not available, place the unit in a strong carton that is at least six inches larger in all three dimensions than the unit. Fill the carton equally around with resilient packing material (shredded paper, excelsior, bubble pack, etc.). Seal it with gummed paper tape, tie it with a strong cord, and ship it by prepaid express, United Parcel Service, or insured parcel post to the address given previously. Mail the original of the letter in a second envelope to that same address.

It is important that the shipment be well-packed and fully insured. Damage claims must be settled between you and the carrier and this can delay repair and return of the unit.

All shipments to us must be PREPAID. We *do not* accept collect shipments. After the unit has been repaired, we will send it back to you COD unless you have prepaid the bill. Unclaimed or refused COD shipments will not be reshipped unitl payment in full is received. These items become the property of Hy-Gain 60 days after refusal or return and will be sold for payment of charges due.

Units with unauthorized field modifications cannot be accepted for repair.

Purchase of Parts

Parts can be purchased from any Hy-Gain Service Center or from the factory Warranty Service Department. When ordering, please supply the following information:

1. unit model number
2. unit serial number
3. part description
4. part number

Specifications

General

Channels	all 23 channels in the Citizens Band (26.965 MHz - 27.255 MHz)
Antenna impedance	50 ohms, nominal
Dimensions (HWD)	3 ¾" x 7 ¼" x 12 ¼"
Power requirement	120 VAC, 50/60Hz, or 240 VAC, 50/60Hz with modification or 13.8 VDC
Compliance	Type accepted under FCC Rules, Part 95

Receiver Section

Circuitry	dual conversion superheterodyne with rf amplifier stage and 455 kHz ceramic filter
Sensitivity	0.7uV for 10dB (S+N)/N ratio
Intermediate frequencies	1st IF - 11.275 MHz 2nd IF - 455 kHz
Audio output	3 watts, maximum
Current drain, receive	about 100 mA (no signal)

Transmitter Section

RF power output	4 watts
Emission	AM, type 6A3
Spurious response rejection	all harmonic and spurious suppression better than FCC requirements
Modulation	AM, 90% typical
Current drain, transmit	less than 1 amp @ 13.8 VDC

CHAPTER 2 - THEORY OF OPERATION

General

The theory of operation of the Hy-Gain VII is divided into four sections: the Crystal Matrix Frequency Synthesizer, the Receiver, the Transmitter, and the Power Supply. The material presented covers the functioning of the transceiver with a minimum of technical involvement. It is intended to be informative but we have not attempted to explain the engineering techniques and approaches that arrived at the circuit designs.

Refer to the block diagram, Figure 2-1, for visual reference to the theory of operation.

Crystal Matrix Frequency Synthesizer

The Crystal Matrix Frequency Synthesizer is a heterodyne oscillator that generates synthesizer frequencies for use in both the transmitter and receiver sections. Its output determines the channel on which the transceiver is operating.

The output of the synthesizer is determined by the particular pair of crystals from the crystal matrix that are selected by the channel selector switch, SW1. This switch is set up so that SW1b switches to the next crystal each step, while SW1a switches to the next crystal every fourth step. There are twenty-four pairs possible. The twenty-fourth position of the switch, located between channels 22 or 23, is blank.

The outputs of the 23 MHz Oscillator, Q1, and the 14 MHz Oscillator, Q3, are applied to the. Synthesizer Mixer, Q2, to produce the 23 required synthesizer frequencies.

The synthesizer frequency produced by the Synthesizer Mixer is applied to both the Transmit Mixer, Q5, and the First Receiver Mixer, Q13.

Receiver

The receiver is a dual-conversion superheterodyne, receiving AM signals from 26.965 MHz to 27.255 MHz. The operating channel is determined by the crystal matrix frequency synthesizer, which provides the first local oscillator frequency. A variable squelch circuit is included to quiet the receiver between transmissions.

In the receive mode, 18.8 VDC is supplied to IC1, Q12, Q13, Q14, Q15, and to Q10 (the AVR). The AVR supplies regulated voltage to the synthesizer stages, Q1, Q2, and Q3, and to the Second Local Oscillator, Q16. A bias voltage is also applied to the base of the Transmit Switch, Q11. The bias holds the Transmit Switch open, so that the transceiver circuits remain in receive.

AM signals are received by the antenna and enter the radio at the antenna jack. The pi-filter formed by L8, L9, C33, and C1 of the rear panel matches the antenna impedance to the RF Amplifier, Q12. Signals in the 26.965 MHz - 27.255 MHz range are filtered out and amplified by the 26.965 MHz - 27.255 MHz range are filtered out and amplified by the RF Amplifier and the tank circuit, C37/L10, that precedes it.

The output of the RF Amplifier and the synthesizer frequency, which in this case could be called the "first local Oscillator," are applied to the First Receiver Mixer, Q13.

The first set of two signals is mixed in the First Receive Mixer for an output of 11.275 MHz, which is the first i-f.

The second i-f is fed to the Ceramic Filter, CF. It is then amplified by Q14 and Q15, which are the Second IF, First Stage Amplifiers, respectively. The amplified signal is fed to the Detector, D8. (D5 is a signal overload protector.) The Detector recovers the audio from the modulation signal to yield an af output. The output is applied to the Automatic Noise Limiter (ANL), D6, and the Squelch Switch, Q19.

The squelch functions in the following manner. In the receive mode, a bias voltage from Q10 is applied to the base of Q19, as determined by VR2. In the absence of a signal, the base of Q19 is positive biased and activates. This biases the squelch transistor inside IC1, which turns off the Audio Amplifier and results in squelching of the receiver.

The output of the ANL goes through the volume control, VR1, and is RC-coupled to the Audio Amplifier, IC1. The amplified af output from IC1 goes through the audio transformer, T1, to be applied to the speaker jacks and the speaker.

Transmitter

The operating channel is determined by the crystal matrix frequency synthesizer. The synthesizer frequency is heterodyned with the offset oscillator frequency to yield the transmit frequency. This frequency is then amplified by a three-stage power amplifier.

T/R switching to the transmit mode is done in the following manner. When the PTT switch is closed, the base of the Transmit Switch, Q11, is grounded by that switch. This prevents biasing of Q11, and it is closed. Regulated voltage from the Automatic Voltage Regulator (AVR), Q10, can then be supplied through Q11 to Q4, Q5, Q6, and Q7. Because the RF Power Amplifier is a class C type, it will conduct only when rf is applied to the bases of Q8 and Q9. It is not necessary to provide switching for the 13.8 VDC that is supplied to it at all times. With the PTT switch closed and rf applied to Q8 and Q9, the transceiver is in the transmit mode.

The transmit frequency from this mixer passes through the filter circuit of L4 and L5 and is then applied to the Pre-drivers, Q6 and Q7. This filter circuit removes part of the undesirable spurious signals from the transmit frequency.

The Pre-drivers of Q6 and Q7 and the Driver, Q8, form two stages of voltage amplification leading to the final stage. The filter circuit of L6 follows Q6, and L7 follows Q8. These two circuits filter out the remainder of the spurious signals from the transmit frequency.

From the Driver, the signal is applied to the third stage of amplification, the RF Power Amplifier, Q9. This is a current amplifier that raises the transmit signal to an output of four watts. Its output is applied to the pi-filter of L8, L9, C1 of the rear panel, and C3, and then to the antenna jack. The pi-filter constitutes an antenna impedance-matching circuit.

The transmit signal is modulated in the following manner. Microphone output is applied to the Audio Amplifier. The resulting af is applied to the collectors of Q8 and Q9 through the secondary coil of the audio output transformer, T1.

Control voltages for the Transmit Audio ALC, Q17, and the Range Boost, Q18, are obtained from detector diode D10. The Transmit Audio ALC boosts, or lowers, the amplifier gain in response to line voltage fluctuations. This insures full modulation of the carrier despite any changes in line voltage. The Range Boost rolls off af peaks so that a higher average af level is supplied to the Audio Amplifier. This achieves the high average modulation desired at the output of Q9 without an overmodulation of the peaks.

Power Supply

This is a series-regulated power supply circuit employing a pair of transistors as the pass element. The bridge rectifier of D1 - D4 supplies 22.1 VDC to the high-gain pass element of Q1 and Q3. Zener diode ZD2 provides a voltage reference for Q2. Q2 is a current regulator for the pass element. The base of Q2 is biased by the output of Q3. This feedback loop enables the output voltage of Q3 to be held at a constant 13.8 VDC, when RV1 is set.

CHAPTER 3 - ALIGNMENT

General

The following procedures must be followed in order to align the Hy-Gain VII transceiver. Alignment should not be undertaken unless the technician has adequate test equipment and a full understanding of the transceiver circuitry.

IMPORTANT: Tuning adjustment of this transceiver "shall be made by or under the immediate supervision and responsibility of a person holding a first- or second-class commercial license," as stipulated in Part 95.97 (b) of the FCC Rules and Regulations.

The procedures are divided into two main sections: Receiver Alignment, and Transmitter Alignment. See Tools and Equipment below for a complete list of recommended equipment.

These procedures assume that voltages are present at all points of the unit. If not, troubleshoot before continuing.

NOTE: The ferrite cores in the tuning coils are easily chipped or broken. Use care when inserting an alignment tool in the tuning coil: insert it straight into the core.

Tools and Equipment

The following tools and equipment are recommended for use in aligning the Hy-Gain VII. All equipment must be correctly calibrated.

RF VTVM

Frequency Counter

Watt Meter

50 ohm 5 watt dummy load

DC Power Supply

Wiring Model 3077 for 240 VAC

WARNING: Disconnect the unit from the power source before attemping any wiring changes.

NOTE: See Figures 3-1 and 3-2 for wiring changes.

1. Remove the top and bottom cover by removing the five screws found in each cover. Remove the knobs from the front panel.

2. Unsolder the blue lead from the fuse holder and the white lead from the AC receptacle.

3. Solder the two leads together.

4. Insulate the connection and reassemble the unit.

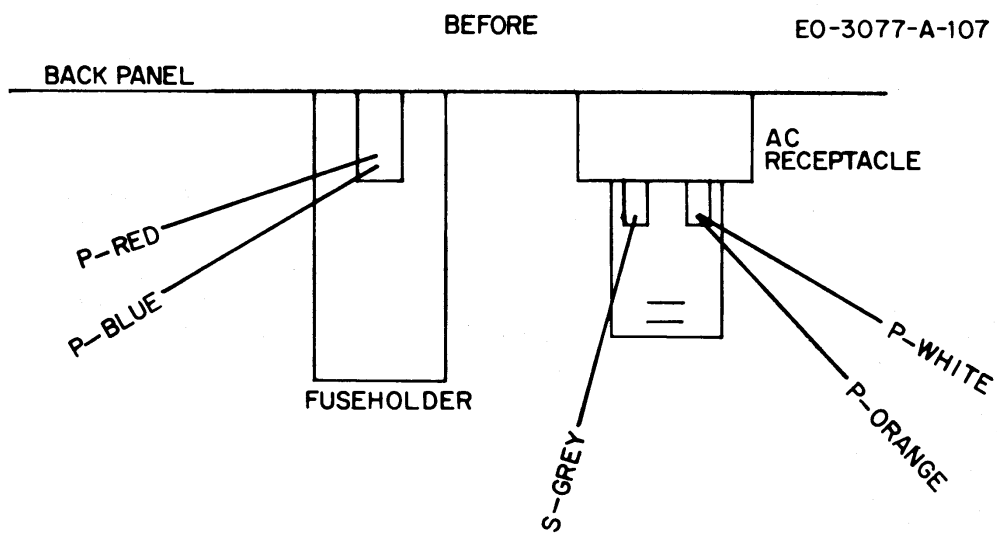

Figure 3-1

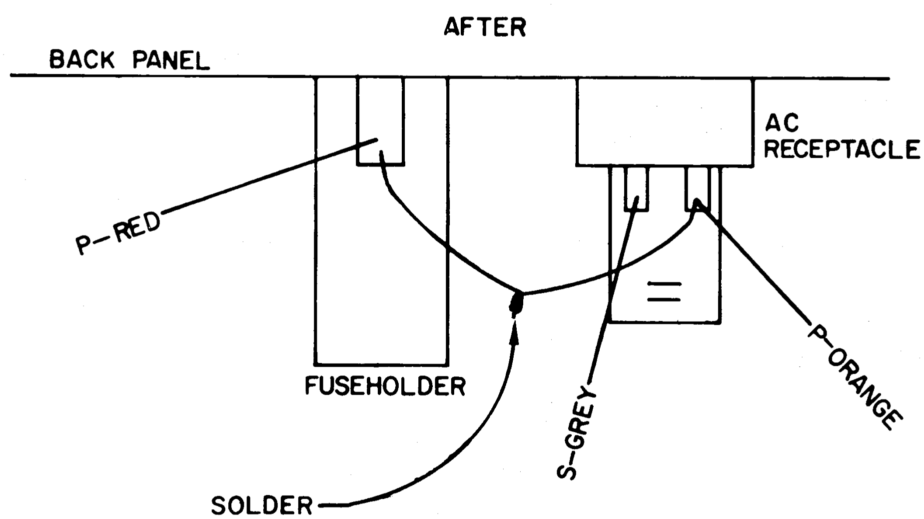

Figure 3-2

Transmitter Alignment Procedures

Equipment Set-up

Refer to Figure 3-6 for components to be adjusted for transmitter alignment.

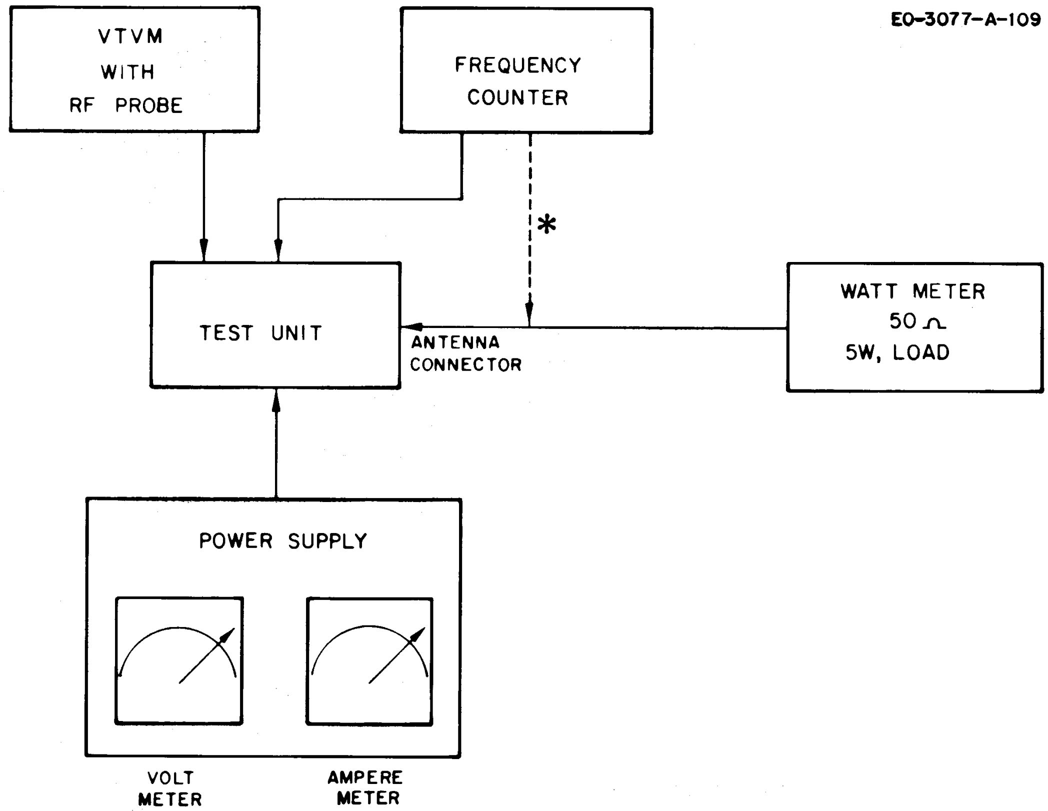

Figure 3-3
Equipment Set-up, Transmitter Alignment

*See Figure 3-4 for connection of the frequency counter and the dummy load.

Output Frequency Check and Adjustment

1. Turn the transceiver on. Set the channel selector on channel 13.

2. Key the transmitter with the microphone PTT button.

3. Adjust L1 so that its core is flush with the top of the can.

4. Touch the RF VTVM probe to the emitter of Q1, turn the core of L1 clockwise until a jump in emitter voltage is observed. Turn the core of L1 one-half turn further clockwise beyond that point.

NOTE: To insure accurate readings, be sure to connect the VTVM ground lead to a p.c. board ground, not the chassis frame.

5. The frequency may be checked by touching the frequency counter probe to the emitter of Q1, there will be a reading of 23.440 MHz ± 300 Hz.

NOTE: Use a low capacity probe when measuring these frequencies. A high capacity probe can cause the oscillators to go off-frequency.

6. The 14 MHz Oscillator may also be checked at this time. Touch the frequency counter probe to the collector of Q3. There should be a reading of 14.950 MHz ± 300 Hz.

A. Frequency Check

1. Turn the transceiver off.

2. Connect the dummy load and frequency counter to the antenna jack as shown below:

E0–0672–A–010

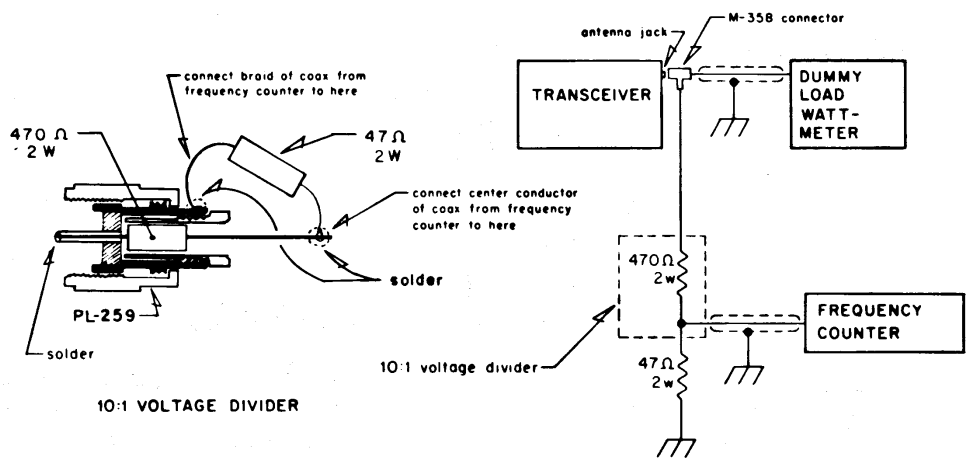

Figure 3-4

3. Key the transmitter with the microphone PTT button.

4. Check the Frequency of each channel with the chart below:

CHANNEL FREQUENCY

Channel	MHz	Channel	MHz
1	26.965	13	27.115
2	26.975	14	27.125
3	26.985	15	27.135
4	27.005	16	27.155
5	27.015	17	27.165
6	27.025	18	27.175
7	27.035	19	27.185
8	27.055	20	27.205
9	27.065	21	27.215
10	27.075	22	27.225
11	27.085	23	27.255
12	27.105		

5. If all the frequencies tend to be off in the same direction, follow B below. If a multiple of four or six channels are off, follow the procedure of section C.

B. Adjusting the Offset Oscillator

1. To raise all the channel frequencies - check for a jumper installed at C13 or C14, either above or below the p.c. board. If present, remove it, install a 270 pF capacitor at C13, and recheck all channel frequencies. If they still need to go higher, replace C13 with a lower-value capacitor and then check all frequencies again.

2. To lower all the channel frequencies - check for a jumper installed at C14, either above or below the p.c. board. If present, the frequency cannot be lowered because it is already as low as it can go. In this case, replace X11 and then go back to Part A, Step 4. If there is no jumper, replace C13 with a higher value capacitor and recheck all channel frequencies. If the frequencies are not low enough, replace C13 and C14 with a jumper and recheck all channel frequencies.

3. Unkey the transmitter.

C. Correcting Synthesizer Frequencies

1. Determine which channels are off-frequency and replace the appropriate crystal with a good crystal as indicated in the chart below.

Off-frequency or Defective	
CH 1-4	X1 - 23.290 MHz
CH 5-8	X2 - 23.340 MHz
CH 9-12	X3 - 23.390 MHz
CH 13-16	X4 - 23.440 MHz
CH 17-20	X5 - 23.490 MHz
CH 21-23	X6 - 23.540 MHz
CH 1, 5, 9, 13, 17, 21	X7 - 14.950 MHz
CH 2, 6, 10, 14, 18, 22	X8 - 14.960 MHz
CH 3, 7, 11, 15, 19	X9 - 14.970 MHz
CH 4, 8, 12, 16, 20	X10 - 14.990 MHz

2. Recheck all channel frequencies.

3. Unkey the transmitter.

RF Output Adjustment

1. Set the channel selector on channel 13.

2. Key the transmitter with the PTT button.

3. Reduce the external power supply voltage for a wattmeter reading of exactly 0.5 watt.

4. Adjust L2, L3, L4, L6 and L7 for maximum readings on the wattmeter.

5. Repeat step 4 until no further improvement is observed.

6. Change the channel selector to channel 23 and raise the external power supply voltage to 13.8 VDC.

7. Adjust L8 and L9 for maximum readings on the wattmeter.

8. Repeat step 7 until no further improvement is observed.

9. Back off 9 (counterclockwise) for a reading of 4.0 watts.

10. Maximum total DC supply voltage at this setting must not exceed 950 mA. Measure this with the DC Ammeter in the power supply or with an external ammeter connected in series with the external power supply line. Readjust L8, if necessary, to meet this requirement.

Modulation Adjustment

1. Connect the oscilloscope probe to the center lead of the backside of the antenna jack. Connect the ground lead to the chassis wrap-around.

2. Key the transmitter with the PTT switch and whistle into the microphone. Note the oscilloscope display and adjust RV2 for 90% modulation (valleys are 90% of peaks).

3. Unkey the transmitter.

Spurious Frequency Check

1. Key the transmitter with the PTT switch and whistle into the microphone. Note the oscilloscope display. There should be no irregularities on any portion of the wave pattern.

2. Repeat the RF Output Adjustment procedure if any irregularities are noted.

Meter Adjustment, Power Scale

1. Key the transmitter with the PTT switch. Adjust RV4 for the same reading on the transceiver meter power scale as shown on the wattmeter.

Receiver Alignment Procedures

Refer to Figure 3-7 for the location of components adjusted for receiver alignment.

Connect test equipment as shown below.

Equipment Set-up

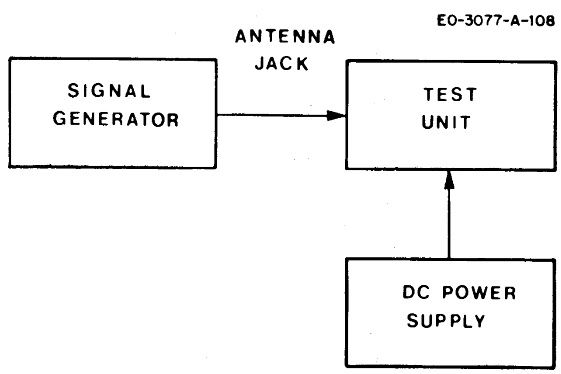

Figure 3-5
Equipment Set-up, Receiver Alignment

Sensitivity Adjustment

1. Turn the transceiver on and set the channel selector to channel 13. (27.115 MHz)

2. Set the signal generator frequency for 27.115 MHz with 1 kHz, 30% modulation. Set the attenuator at minimum.

3. Raise the signal generator attenuator output to at least 10 uV (or as much as 100 uV, if needed).

4. Adjust coils L10, L11, L12, L13, L15, and L16 for maximum reading on the transceiver meter.

CAUTION: If you begin adjustment with more than 10 uV, reduce the output level of the signal generator as the receiver cans are peaked to prevent readings from exceeding full scale.

5. Repeat step 4 until no further improvement is obtained.

Tight Squelch Adjustment

1. Set the signal generator frequency for 27.115 MHz with 1 kHz, 30% modulation and the attenuator set at minimum.

2. Set the channel selector on channel 13 (27.115 MHz). Set the squelch control on tight (fully clockwise).

3. Raise the signal generator attenuator output to 100 uV.

4. Adjust RV1 so that tight squelch just breaks with the 100 uV input.

S-Meter Adjustment

1. Set the RF signal generator attenuator output at 100 uV.

2. Adjust the RV3 for a meter reading of 9 on the upper scale.

3. Turn the transceiver off and disconnect the test equipment. This completes the receiver alignment

Power Supply Adjustment

1. Connect the unit to the 60 Hz line.

2. Adjust RV1 until a reading of 13.8 volts is measured across C4 on the voltage regulator board.

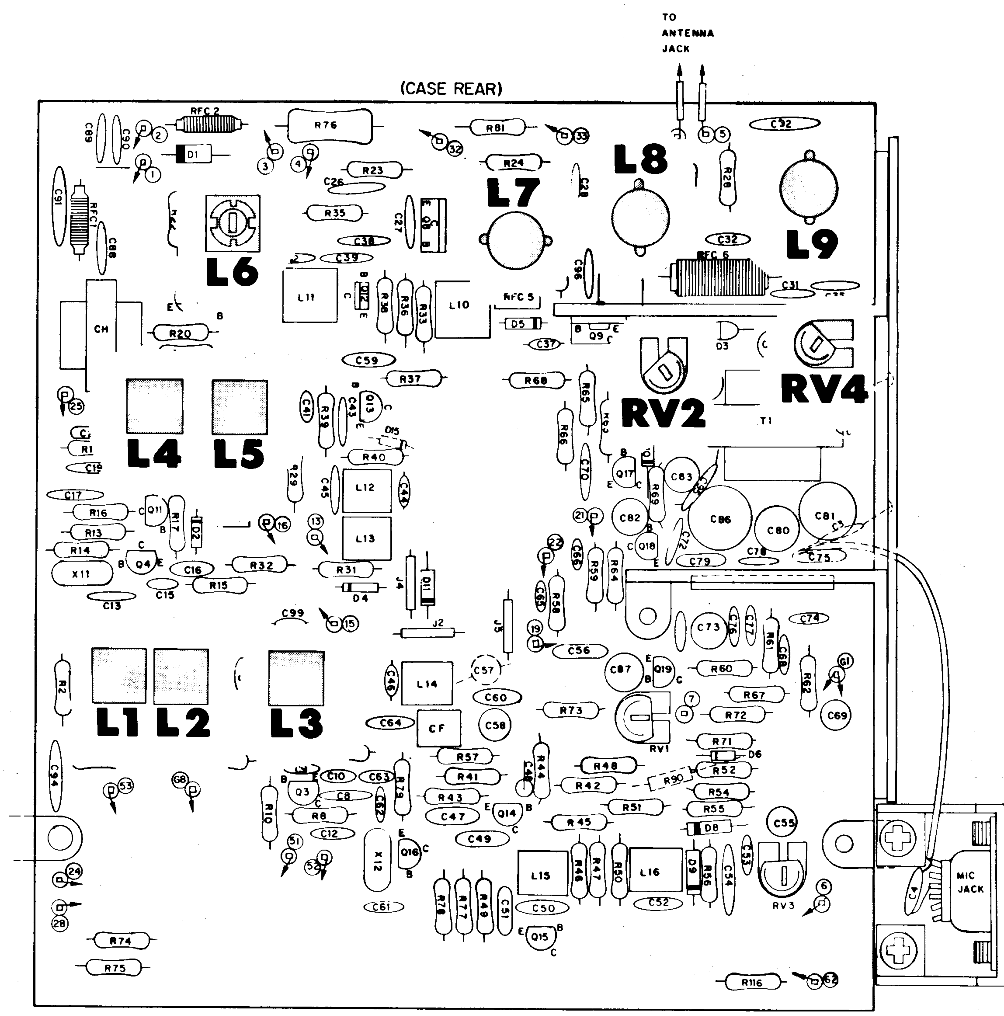

Figure 3-6. Components Adjusted for Transmitter Alignment

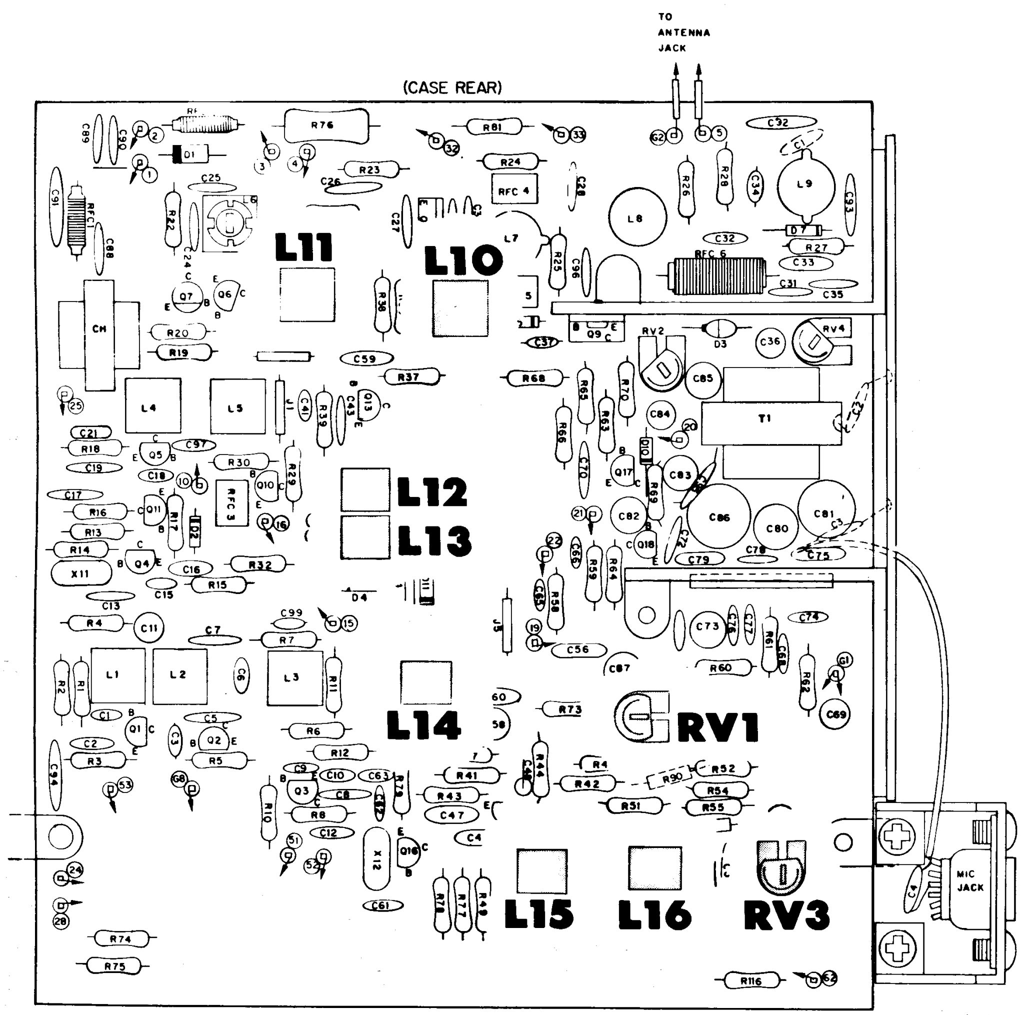

Figure 3-7. Components Adjusted for Receiver Alignment

CHAPTER 4 CHARTS AND DIAGRAMS

VOLTAGE MEASUREMENT CHART

Reference Designator	Mode	E	AM B	C
Q1	Tx	3.1	1.9	8.5
	RX	3.1	1.9	8.5
Q2	TX	3.0	2.0	8.5
	RX	3.0	2.0	8.5
Q3	TX	2.1	2.6	8.5
	RX	2.1	2.6	8.5
Q4	TX	2.03	2.5	8.2
	RX	0	0	0
Q5	TX	1.2	1.7	8.7
	RX	0	0	0
Q6	TX	2.0	2.6	13.5
	RX	0	0	13.8
Q7	TX	1.46	2.0	23.8
	RX	0	0	13.8
Q8	TX	0	-0.17	9.9
	RX	0	0	13.4
Q9	TX	0	-0.06	9.6
	RX	0	0	13.4
Q10	TX	8.8	9.4	12.2
	RX	8.8	9.4	13.2
Q11	TX	8.8	8.0	8.7
	RX	8.8	8.1	0
Q12	TX	0.3	0.33	13.4
	RX	1.5	2.06	12.6
Q13	TX	0.06	0.33	13.3
	RX	1.6	2.0	11.5
Q14	TX	0	0.3	13.3
	RX	1.5	1.85	11.4
Q15	TX	0	0.2	13.3
	RX	0.7	1.3	12.8
Q16	TX	0	0.3	0.8
	RX	1.75	2.24	6.5
Q17	TX	0.04	0.65	0.06
	RX	0	0.6	0
Q18	TX	0	0.06	0
	RX	0	0	0
Q19	squelched	0	0.6	0
	unsquelched	0	0	3.2

Power Supply

Ref.Des.	Mode	E	B	C
Q1	RX	0	-0.04	-0.04
Q2	RX	0	0	-0.03
Q3	RX	0	0	-0.03

IC 1

Mode	1	2	3	4	5	6	7	8	9	10
RX	13.8	12.9	4.0	12.0	0.5	1.95	1.4	0	0	10.9
TX	13.4	12.3	4.0	8.0	1.4	1.6	3.4	1.4	0	6.9

NOTE: All voltage measurements are taken with the internal power supply set at exactly 13.8 VDC.